

TUNNEL VISION ITS CAUSES & TREATMENT STRATEGIES

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Abstract

Tunnel vision, also referred to as visual perceptual narrowing, is a process that occurs when one is visually aware only of central visual information, while simultaneously ignoring or being unaware of information located in the peripheral field of vision. During this process, high attention and detailed focus is concentrated on central processing, while awareness of peripheral information is suppressed or ignored. Tunnel vision is a response to certain types of stressors, and is closely linked to visual attention factors. Some of the research on tunnel vision, as well as treatment techniques to regain peripheral awareness following tunnel vision, is summarized.

Key Words

attention, awareness, body alarm reaction, central vision, combat stress, fovea, neurological stress, perceptual narrowing, peripheral vision, parafovea, syntonics, tunnel vision, visual training

INTRODUCTION

Tunnel vision, or visual perceptual narrowing, is most commonly associated with the perceptual changes accompanying an intense and sudden assault on an individual. It results in an extensive neurological reaction. These perceptual changes often are reported during combat situations where the body alarm reaction is activated. This reaction can be defined as the neurological, biochemical, hormonal and behavioral changes that occur when the body and mind face “flight or fight” encounters.¹⁻³ I have found that military personnel and police facing combat situations, often report that they become so focused on the threat of attack, so that all attention is centered on a relatively small area of the visual field. This extreme focus and attention to the details of a perceived attacker results in perceptual narrowing. At worst it is complete unawareness of visual information beyond the central area of attention. It is as if one is looking through a cylindrical tube while viewing a visual scene. This type of tunnel vision serves a useful purpose when it is a temporary perceptual constriction that dissipates after an action has been taken to resolve a potentially life threatening situation.

Perceptual narrowing has also been associated with chronic stress conditions that are not life threatening.^{4,5} These stressors can eventually result in a restricted perceptual life style that negatively affects the individual’s ability to learn and/or move effectively in the environment. It is more commonly seen in individuals who feel they must live through and endure long-term stressful situations, such as emotional or relationship instabilities, job dissatisfaction, environmental

stressors at school or at work, and chronic health problems. Another more recent cause is the Computer Vision Syndrome (CVS), that is defined as, “the complex of eye and vision problems related to near work which are experienced during or related to computer use. CVS is characterized by visual symptoms which result from interaction with a computer display or its environment. In most cases, symptoms occur because the visual demands of the task exceed the visual abilities of the individual to comfortably perform the task.”⁶

However, perceptual narrowing is not always a negative. It has advantages during certain visual activities. For example, in sports vision, while trying to hit a fastball, or throwing a dart in the ‘bull’s eye,’ the constriction of visual focus and attention to a narrow, central field of view enhances in the precise visual-motor control necessary for success. When an athlete is able to choose the appropriate mode of visual attention along a central-peripheral continuum, the result will lead to enhanced visual-motor control. Learning techniques and strategies to activate and/or suppress perceptual narrowing can be a distinct advantage while engaging in a variety of sports.

Research on perceptual narrowing resulting from stressors

There are numerous studies that support the concept that various types of stressors have the potential to cause perceptual narrowing. Forrest stated:

Esterbrook (1959) hypothesized that high arousal results in a narrowing of attention from secondary peripheral information toward the central information coming from a primary task. While Esterbrook considered this narrowing of attention to be a relatively passive and automatic process,

*Eysenck (1982) proposed that it could be viewed as an active coping response. Eysenck also sees anxiety as being a major factor leading to a narrowing of attention concomitantly resulting in the tuning out of peripheral information.*⁷

Forrest further explained his rationale behind the mechanisms related to peripheral narrowing:

*Tension increases anxiety and is increased by anxiety. It induces a more narrowed focal, discrete, central processing style and is increased by the exclusion from awareness of peripheral stimuli. Tension also fosters selective rigidity in body function and in mental action.*⁷

Some 196 collegiate athletes were the subjects in study measuring changes in anxiety, visual perception and reaction time during stressful situations. It was found that athletes who showed the greater amounts of peripheral narrowing during stress, coupled with more negative life event situations, incurred more athletic injuries than those with the opposite findings.⁸

In another study, the investigators used tone counting tasks. Here, randomly selected high or low sounds were presented and the subjects were asked to keep track of the number of low sounds they heard. The stimuli were increased in numbers so that the task was gradually made to induce light, medium or heavy mental tasks. As the task demand increased, the level of mental effort was found to increase overall stress in an attempt to maintain high performance. Goldmann perimetry showed that, as compared to the light task demand, the mean area of visual fields were reduced to 92.2% in the medium condition and to 86.41% during the heavy workload condition. This tunneling effect also showed shape distortions and was not uniform in all meridians.⁹

Researchers at the University of Nottingham asked novice and experienced automobile drivers to search video clips taken from a moving driver's perspective for potential hazards while responding to peripheral target lights. They found that increased visual demands in the dynamic scenes led to a reduction in the ability to detect targets at varying peripheral eccentricities. Results clearly showed that the ability to accurately respond to the

peripheral target lights decreased for all participants as processing demands increased (i.e. when hazards occurred). Thus, increased visual demands were linked to increased stress levels. The study also demonstrated that peripheral detection abilities varied with driver experience. This suggests that the spread of attention given to a driving scene improves with experience. However, the overall results indicate that the degradation of peripheral field occurs when it is most needed.¹⁰

It has been established that life threatening stressors initiate a series of neurological and biochemical reactions that is coordinated by the hypothalamus.¹ The structure initially activates the sympathetic branch of the autonomic nervous system resulting in the stimulation of the adrenal medulla to release adrenalin. Adrenalin causes increased heart rate, increased respiration and increased sweat gland activity. Concomitantly, sympathetic nervous system changes can affect the eye, causing papillary dilation, a slight bulging of the eyes and negative accommodation. These automatic reactions can be said to posture the body for engagement with a perceived lethal threat stimuli.

The hypothalamus also activates the release of various hormones to further prolong the ability for the body to remain in a state of high alert. The anterior and posterior pituitary glands are activated by the hypothalamus. The anterior pituitary in turn activates the adrenal cortex to release mineralocorticoids and glucocorticoids. Cortisol is the most abundant glucocorticoid released by the anterior pituitary.¹¹

The posterior pituitary releases vasopressin, which works on the vascular system to increase blood pressure, and also affects the kidney in order to maintain water balance throughout the body. These physiological changes allow a person to maintain a high state of physiological readiness until such time that the perceived threat is dissipated. Once the threat has been successfully contained, a feedback loop back to the hypothalamus allows for changes in neural and biochemical pathways to allow for a more relaxed, physiological balance to be restored to the body. Activation of the parasympathetic nervous system is the major factor that helps restore neurological balance.¹²

Current psychopharmacological research indicated that cortisol can impair memory and other processes involved in

perceptual error detection.¹³ The authors concluded that these changes probably reflect an alteration in anterior cingulate cortex activity. Perhaps the increased amounts of cortisol resulting from the stress response contribute to a biochemical mediator in a stress induced tunnel vision response. Considering this research from a functional point of view, it could be easier to have a memory loss of the relatively less distinct visual images in the peripheral retina, as compared to the more detailed, sharper images at the central retina.

Tunnel visual fields have also been associated with chronic, non-life threatening types of stressors. The Streff Non-Malingering Syndrome is associated with a functional decrease of visual acuity, eye tracking and fixation control, as well as restricted or tunnel vision types of visual fields.¹⁴ These functional visual field restrictions are proposed to be related to persistent visual stress. Streff advocated the use of stress-relieving lenses and vision therapy to optimize the basic visual skills to counteract the visual field constriction.

Research on the attentional factors related to tunnel vision

There are various definitions of visual attention used in different scientific disciplines. An optometric journal article on attention proposes that:

*...educators and optometrists are concerned with the length of time a child can attend to a single task. In the vision science literature, visual attention is thought of as an enhancement of visual processing at the location to which attention is directed. In terms of visual neuro-physiology, the definition of visual attention must be restricted. Visual attention may be thought of as a filter that limits the amount of information that the visual system ultimately processes. It determines which information that reaches the retina will be available to higher cortical areas for the final assembly of the perception of the visual world. The rest of the information is relatively 'ignored.'*¹⁵

There are many examples of studies linking the role of attention to perceptual narrowing. For example, Williams reported that identification of letters in the periphery (up to 4.4 degrees from central fixation) was adversely affected when subjects were asked to perform a foveal visual task simultaneously. The degree of

difficulty of the foveal task, as well as the attentional allocation instructions, were important indicators to the extent of the perceptual narrowing. He concludes that tunnel vision can be induced by a combination of high foveal cognitive load, a focused attention strategy, and stress.¹⁶

In another study, Williams found that aviators demonstrated visual field tunneling when a foveal task was sufficiently difficult and reaction time was the principal dependent measure. The study also showed that aviators might be less susceptible than non-aviators to visual tunneling, implying that there may exist a learned component in reducing the degree and permanence of the tunnel vision perceptual constriction.¹⁷

A study in Hong Kong tested the effects of two levels of foveal cognitive loading on tunnel vision. The results indicated that tunnel vision was most prominent when the foveal task was primary. A greater magnitude of tunnel vision was obtained when the more difficult foveal task was performed.¹⁸

These research results lend credence to the concept that tunnel vision is a dynamic process, and is significantly influenced by the extent and degree of the cognitive demand placed on central, detailed visual processing. As a general rule, the more cognitive attentional demand that is placed on a central target the more robust will be the extent of the tunnel vision constriction of peripheral perceptual awareness.

Another study demonstrated that VEP amplitudes are enhanced in response to an attended target as compared to targets that are not the center of attention. This factor suggests that more neural networks are recruited for processing an attended target.¹⁹ An extension of this research model could indicate that tunnel vision is in part attributed to less neural activation of the areas of the brain that correspond to the processing of peripheral visual information. I suggest that this may be the case because most of the neural activity during a stressful event leading to a tunnel vision response is concentrated in areas of the brain corresponding to attention centers controlling central vision processing. Another study using electrophysiological measurements gives credence to this suggestion.²⁰ It used positron emission tomography and found that visual inputs from areas of the field of vision that de-

mand attention receive increased processing in the area of the extra-striate cortex. This finding further reinforces the notion that the brain allows for a prioritized degree of neural circuitry to be allocated for processing visual information. The most circuitry is given to the information requiring the highest attention, so that relatively fewer brain circuits are then available to process visual information from areas peripheral to the central visual attention zone.

METHODS TO COUNTERACT TUNNEL VISION

Tachistoscopic Training

One of the first studies showing that the field of peripheral awareness can be expanded through visual training was conducted by ophthalmologists in 1957. This group demonstrated that tachistoscopic training can increase the size of the peripheral field of view. The study also indicated that tachistoscopic training not only can train humans to process increased visual information more rapidly, but also can be useful to teach people to process a larger volume of peripheral visual space during a single glance.²¹

Other studies point to the fact that tachistoscopic training can reduce the negative consequences that occur during tunnel vision. A landmark study by Renshaw yielded results that illustrated the efficacy of tachistoscopic training in enlarging visual fields. He reported that:

*...with tachistoscopic training there is a significant and large increase in the form-field of the two eyes. The form-field is defined as the solid angle within and beyond the region of the anatomical macula in which an observer is able to see shapes. Form-fields were taken on about 30 subjects before and after tachistoscopic training. Thus far no case has been found which did not show a conspicuous enlargement.*²²

Breathing and Relaxation Techniques

Various of these techniques have proven useful in diffusing the hyperarousal reaction that often leads to tunnel vision. It can be argued that the quicker a person can reverse the sympathetic dominated stress response related to hyperarousal, the less time an individual might remain in the state of perceptual narrowing. Further, a variety of physical and psychological stresses can produce free

oxygen radicals, which in turn, cause oxidative changes within the body. Partial reduction of molecular oxygen can generate reactive oxygen species that include the free radicals superoxide and hydroxyl. The formation of these biochemicals have been linked to diseases such as atherosclerosis and neurodegeneration.²³ A biological equilibrium between the production of oxygen radicals and the counteracting antioxidant defense systems is necessary to eliminate degraded bioproducts. Imbalances in maintaining this equilibrium can result in oxidative stress and subsequent pathological processes.²⁴

One study investigated the effect of yogic breathing exercises (pranayama) on free radicals in a group of young healthy males. The free radical levels were measured before the study and at the end of the study in both a trained group of yogic breathers and a control group. The results confirmed that yogic breathing significantly decreased free oxygen radical levels, as compared to a group of males not using trained breathing techniques.²⁵ Other studies illustrate that learned behaviors, such as controlled breathing techniques and relaxation training, can counter-balance the effects of stressors, and thus help reverse the effects of tunnel vision that are directly linked to sympathetic dominated stress responses.^{26,27}

Enhancement of Peripheral Awareness

Forrest discussed the use of two visual training procedures that are designed to increase a person's ability to improve the identification of visual images in peripheral space. He reported that:

*Training for the 'central' eso processor entails enhancing peripheral meaning-getting ability. Only when that aspect becomes efficient should it be integrated with central activities. Binocular patches are helpful in these cases with the patient being encouraged to look straight ahead toward or into the patches while being aware of the periphery. In this way it helps increase peripheral sensitivity in the eso processor who is weakest in this area. Drawing bilateral chalkboard circles can also be useful provided it is done with a meaningless central fixation target such as a simple X with the emphasis placed on peripheral awareness.*⁷

Scheiman and Rouse discussed techniques for developing visual figure

ground skills.²⁸ The goal is to develop the ability to process and attend to central visual information while maintaining awareness of peripheral or background information. Essentially it involves maintaining awareness of the “forest” while dealing primarily with the “trees.” An example would be with parquetry blocks. Here, the patient views the pattern at one location while he uses individual blocks to reproduce it in another location. Marrone recommended the Macdonald Form Recognition Card and a similar Rothman Card as devices to enhance peripheral awareness.²⁹ These cards have a central fixation target with single alphabet letters radiate in four oblique directions from the central target. The letters increase in size as they are in increasingly peripheral positions. The patient views the central target monocularly and strives to work progressively to recognize more letters.

I have had success using the Wayne Saccadic Fixator^a as a method to build peripheral awareness. Patients view a mirror image of their eyes reflected in the center of the instrument that has light bulbs fixed at its outer perimeter. The lights are illuminated randomly at variable temporal presentations. The task is for the patient to press the button placed adjacent to the light when a he perceives that it is lit, while maintaining central fixation. As the task is successfully performed, the speed at which the lights appear is increased.

A simple yet effective peripheral awareness sports visual training procedure is the peripheral E awareness procedure. A capital letter E about 3 inches high is printed boldly in black on a 4" square, white cardboard. The trainee fixates a central target at a distance of about 20 feet. The trainer places the card so that the trainee grasps it with his fingers and the E is facing the ceiling. The trainee should be unaware of the orientation of the E. The trainee then fully extends the corresponding arm to the side, and progressively rotates it toward his midline until the orientation of the letter is accurately perceived while still maintaining the central fixation target. The goal is to be able to identify the E in its proper orientation at a position as close as possible to full arm extension. The technique can be done monocularly and/or binocularly. The procedure is then repeated with the other hand and arm.

Methods to enhance peripheral awareness can be made increasingly difficult by “loading” the task. For example, the trainee reads the letters of a Hart Chart or similar device placed at an initial distance of about 10 feet from him. As he is doing this, the trainer tosses a ball or bean bag to him from the side. This requires advanced interplay between central and peripheral vision.

Expanding Visual Form Fields With Light Therapy

The College of Syntonic Optometry has been studying and documenting the influences colored light frequencies have on visual function and overall health. The College was founded by Harry Riley Spitler, M.D., Ph.D. in 1933. It remains an active post-graduate educational organization for studying the therapeutic use of selected visible light frequencies applied through the eyes. Spitler's thesis proposes the rationale behind syntonic optometry whereby:

*Syntonic is also used in the adjective form to indicate a balanced integrated nervous system particularly the autonomic in which division there exists a state of dynamic antagonistic tension between its two systems. When these tensions are equal the nervous system is said to be in syntony or in the syntonic state.*³⁰

He discussed the role of the autonomic nervous system in regulating metabolism. Spitler maintained that the parasympathetic division of the autonomic nervous system activates some visceral functions while retarding other metabolic processes. The sympathetic division normally antagonizes the action of the parasympathetic during autonomic nervous system induced metabolic actions. He further explained that life is maintained by successfully adapting to dynamic environmental conditions. This adaptive capacity can only be continued if neural syntony exists resulting in healthy endocrine function.

Spitler outlined evidence that lead to the conclusion that the absorption of radiant light energy through the eyes have a direct relationship to pituitary function, the master gland of the endocrine system. If this relationship is not functioning in a normal manner, he concluded that low frequencies (close to the red end of the spectrum) or high frequencies (close the blue end of the spectrum) of light can produce changes in the following manner: “1. Low

frequencies stimulate the pituitary, decrease the leak in potential and tend to stimulate the sympathetic, producing physiologic activity of the defensive type. 2. High frequencies depress the pituitary, increase the leak in potential and tend to stimulate the parasympathetic producing physiological rest or the vital type activity.”³⁰

A final summary of his research is stated in his syntonic principle number 19: “The ability to continue to live depends upon syntony of the autonomic in both acute and chronic illnesses, and this attainment of syntony may be aided by light frequency into the eye.”³⁰

Functional visual field charting in Syntonic Optometry is not used for pathology detection, although abnormal fields can certainly be indicative of organic pathology. Rather, it is used for determining functional vision deficits. Also, the usefulness of the functional form or color field findings provide evidence of whether the phototherapy treatment is producing desirable changes. It allows clinicians to consider whether the proper frequency (color) or duration of light stimulation is providing the desired results of enlarging the field of vision and improving visual behaviors.

Thus, in Syntonic Optometry, tunnel vision can be conceptualized as a constricted form or color field that is directly related to a stress-induced functional visual field deficit. It is then proposed that the proper application of phototherapy can reduce this stress-related neurologically induced imbalance and reduce the field constriction resulting in an expansion of the functional field of view. It is further proposed that the enlarged field is indicative of a more balanced autonomic nervous system resulting in improved and energy efficient sensory-motor function while processing environmental stimuli. The enlarged form or color fields allow a person to see more, understand more and be generally more aware of activity in a more expansive amount of visual space.

One study explored the changes in form visual fields produced by syntonic stimulation in a group of reading disabled children. The experimental group received colored light treatment. One control group received plain white light treatment, and another group received vision therapy without any type of light treatment. The results indicated the vision

therapy only group increased the size of their form fields by 8.7%, as compared to a 53.1% increase form field size by the children receiving syntonized colored light therapy. The white light control group showed a decrease in the size of their initial form fields. The author concluded that:

*The findings of the study support the hypothesis that children who have significant deficits in reading demonstrate reduced form visual fields. When compared to children who have difficulties in reading primarily due to inefficient binocular vision, the form fields are more reduced in the more severe reading disabilities. Secondly, the choice of appropriate color filters for each of the 10 subjects produced significant changes in the size of the form visual fields.*³¹

The protocols for choosing the appropriate colored filters goes beyond the scope of this paper. Readers are referred to an article by Gottlieb and Wallace that was published in this journal.³²

The idea of light providing health benefits has been widely reported and supported in the scientific literature. Perhaps the most well known relationship of light to health involves using bright light therapy as the recommended treatment for seasonal affective disorder (SAD). An example of SAD research in the psychiatric literature concluded that bright light therapy had a specific antidepressant effect beyond its placebo effect, but it took a minimum of three weeks for a significant effect to develop.³³

CONCLUSIONS

Tunnel vision can be an accompaniment to extreme perceived threat stressors whereby the sympathetic nervous system dominates behavior and hormonal endocrine changes occur via coordination by the hypothalamus. These neural and biochemical changes have the effect of changing how a person attends to detail, with more attention given to central visual detail and less attention available to process peripheral visual information. This type of tunnel vision response normally exists for the duration of the excessive threat stimuli, and once the perceived threat has ended, the tunnel vision also ceases to exist. In this regard it serves a useful purpose. This useful purpose can be potentially harmful if one needs to be visually aware simultaneously of a dangerous stimuli (i.e. an aggressive enemy)

approaching from a peripheral position in space. However, tunnel vision can be present in individuals experiencing more chronic, low-grade visual or other stress, resulting in perceptual narrowing. I have observed this type of patient is frequently an underachiever in school, at work or on the athletic field.

Research has provided an understanding of the biochemical and neurological nature of tunnel vision. Methods to counteract it and its undesired effects include various types of interventions that have been reviewed.

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